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Ultrasonic lubrication: concept and application

Gabriel Zsurzsan, Akio Yamamoto, Michael A.E. Andersen,
Nils Axel Andersen, Zhe Zhang



Dept. of Precision Engineering
The University of Tokyo

DTU Electrical Engineering
Department of Electrical Engineering

$$f(x+\Delta x) = \sum_{i=0}^{\infty} \frac{(\Delta x)^i}{i!} f^{(i)}(x)$$

$$\int_a^b \varepsilon \Theta^{\sqrt{17}} + \Omega \int \delta e^{i\pi} = \{2.7182818284\}$$

$$\chi^2 \sum! >$$

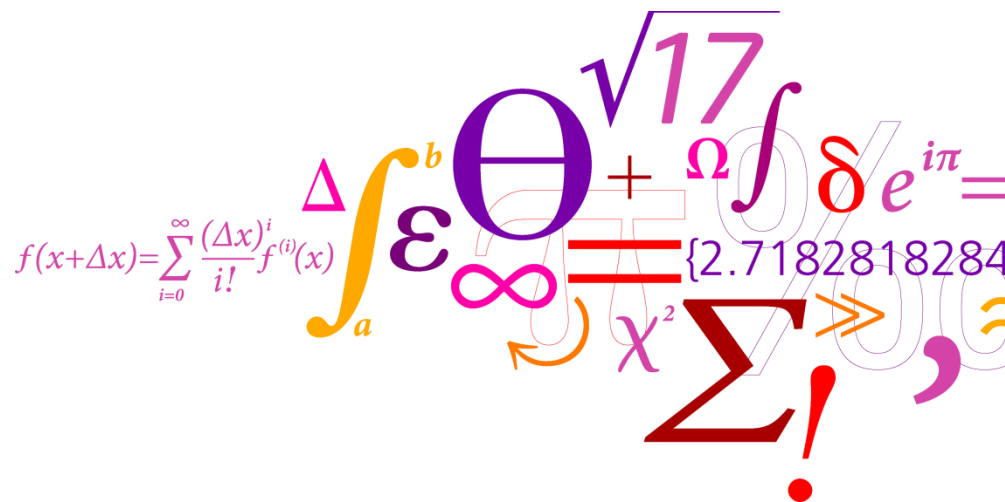
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Technical University of Denmark - DTU

DTU will develop and create
value using the natural
sciences and the technical
sciences **to benefit society.**

H.C. Ørsted, founder of DTU in 1829



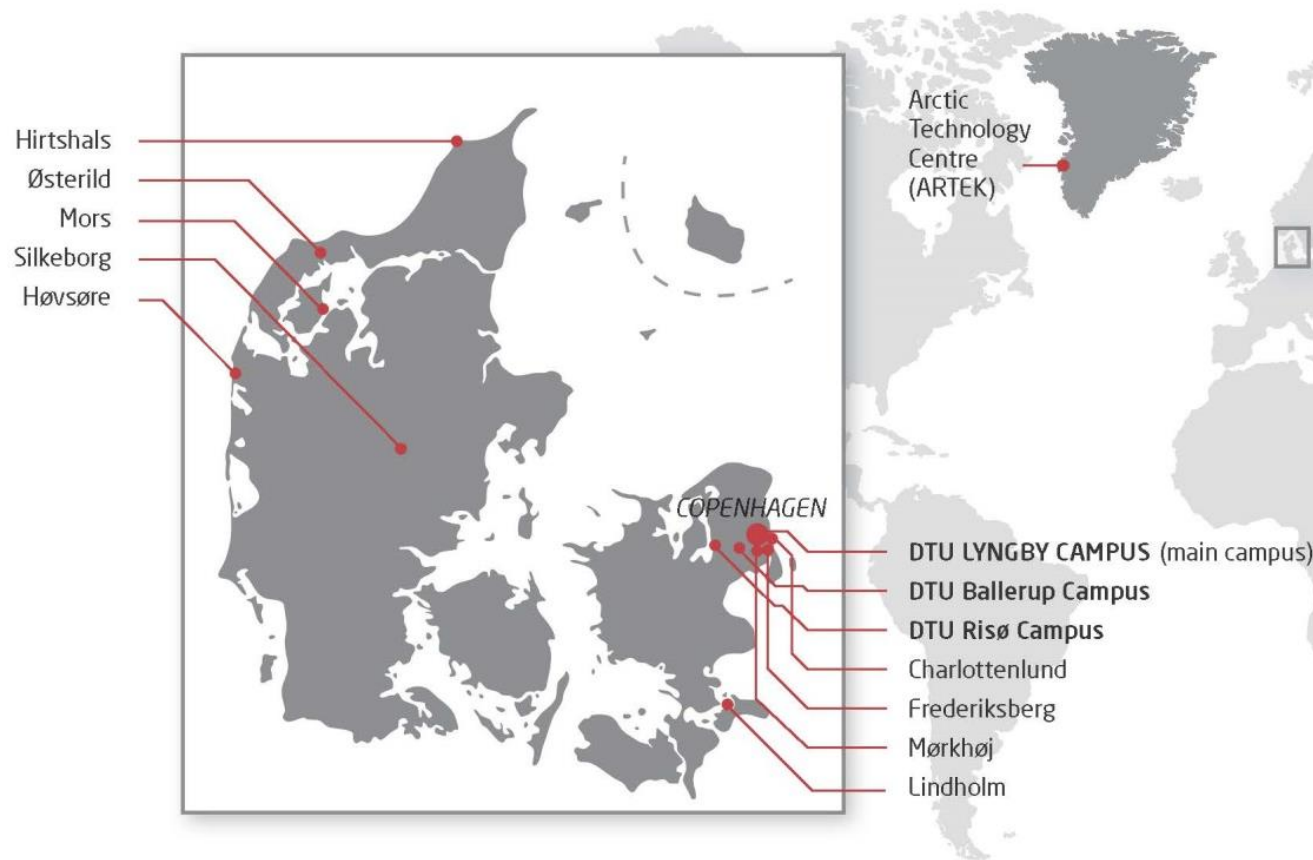
Education

Innovation

Scientific advice

Research

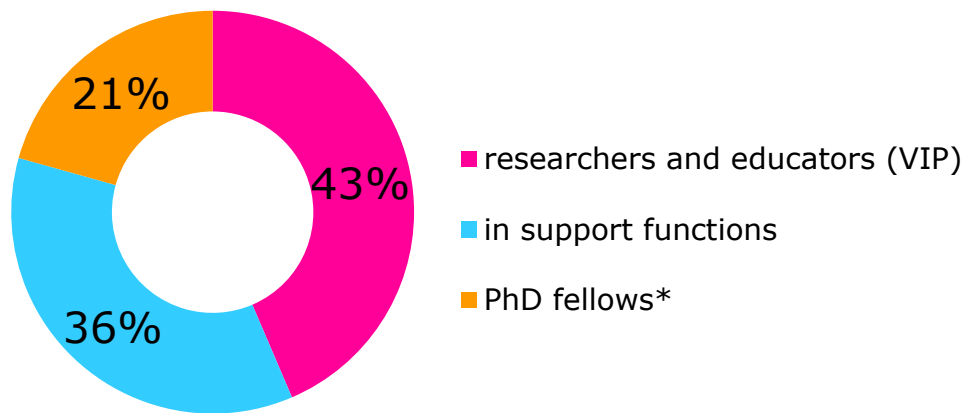
Technical University of Denmark - DTU



Technical University of Denmark - DTU

5,813

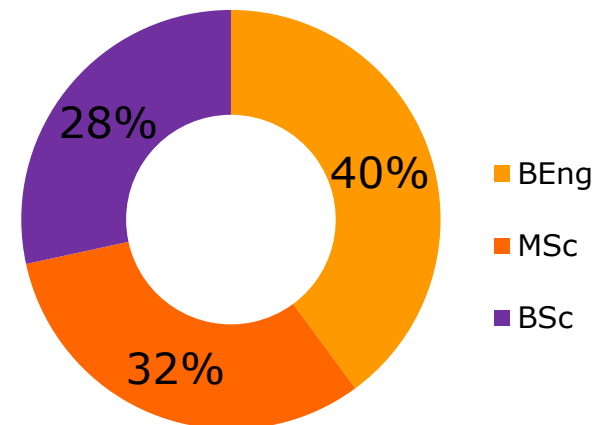
human resources (FTEs)



*Employees only

10,311

full-time students



DTU Electrical Engineering



Power engineering

Automation, control, and robotics

Biomedical engineering, CMR, ultra sound

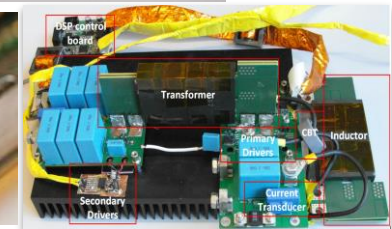
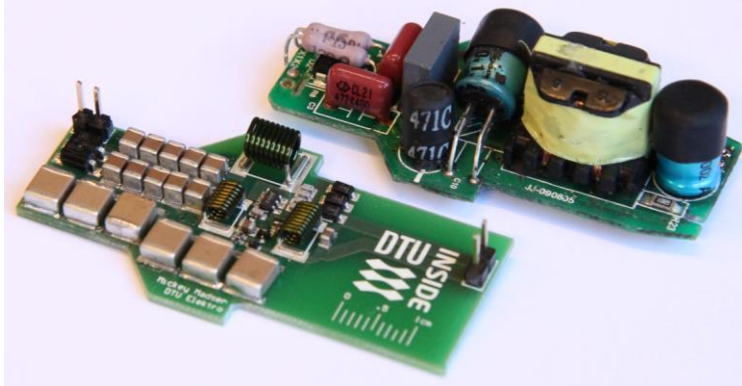
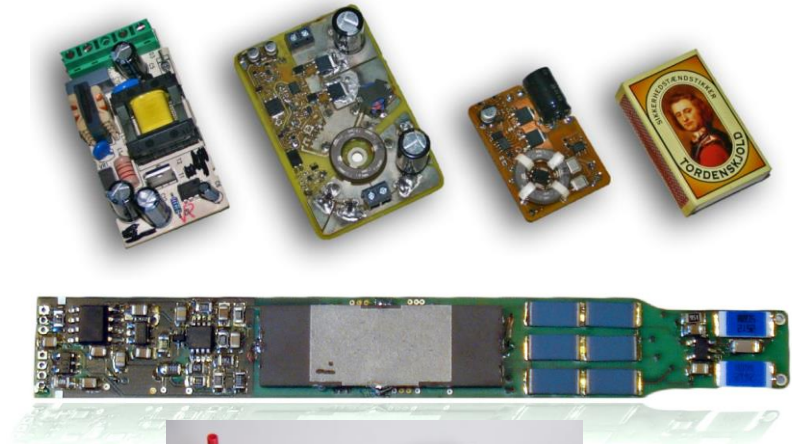
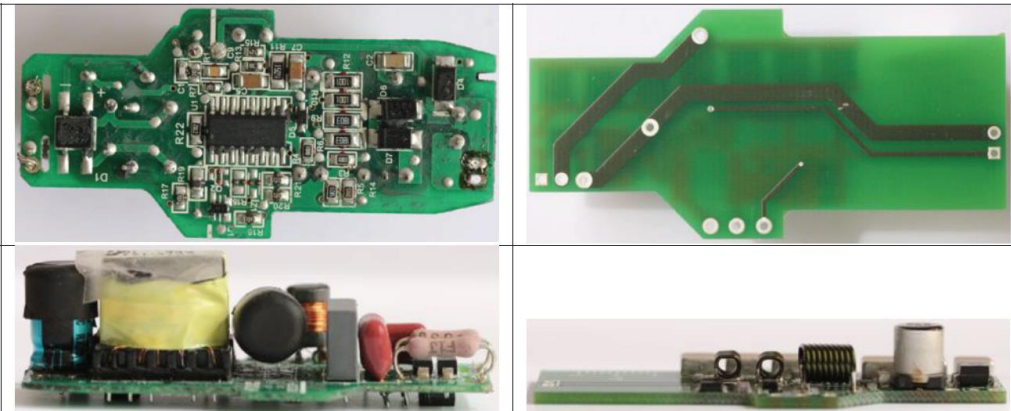
Antennas & microwave tech.

Acoustics

Hearing systems

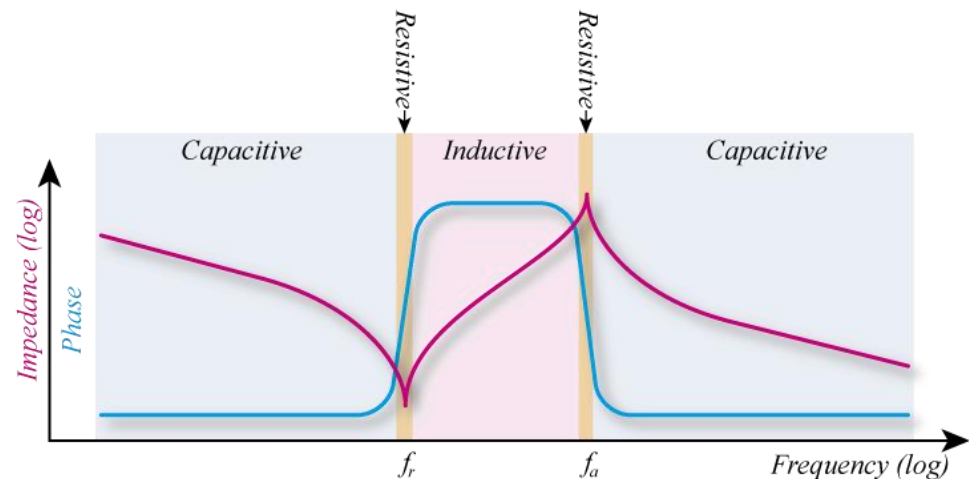
Power electronics & IC design

Electronics group



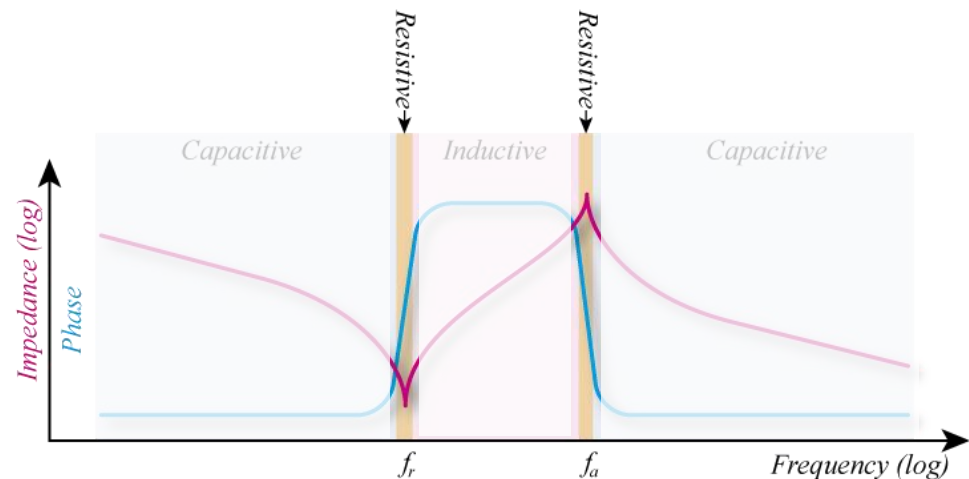
Electrical behaviour of piezos

- **Capacitive behavior**
- **Inductive behavior**
- **Resistive behavior**



Electrical behaviour of piezos

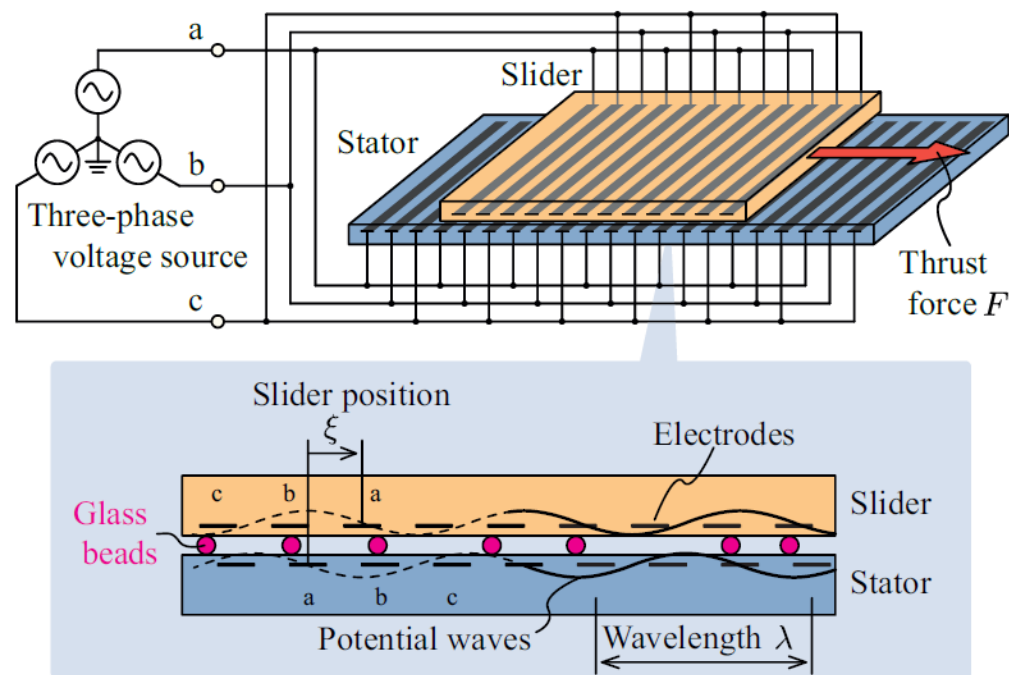
- Capacitive behavior
- Inductive behavior
- **Resistive behavior**



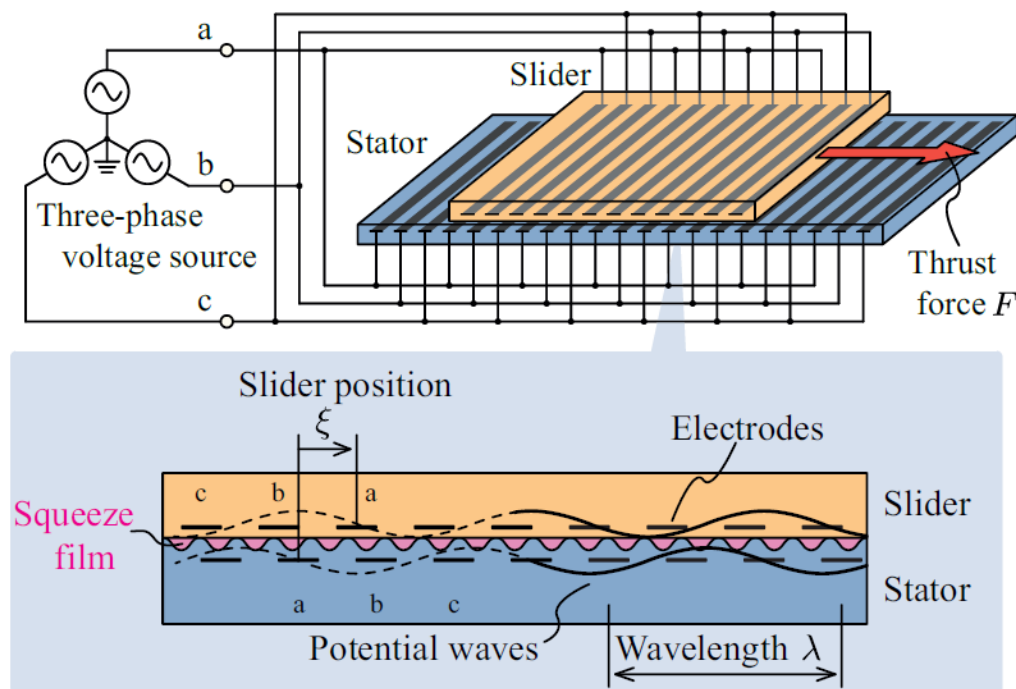
Electrostatic Motor



Electrostatic Actuation

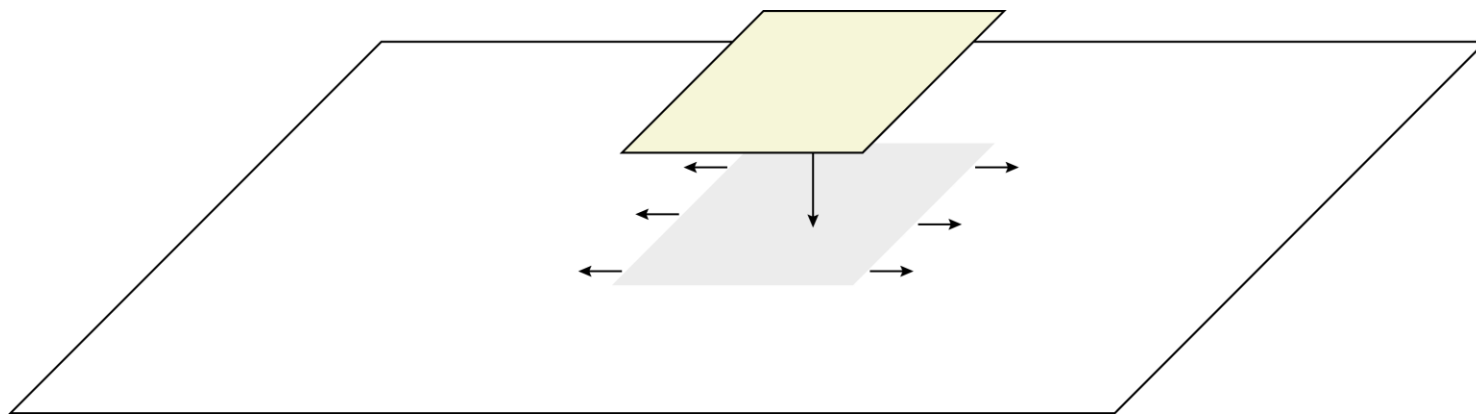


Enhanced Electrostatic Actuation

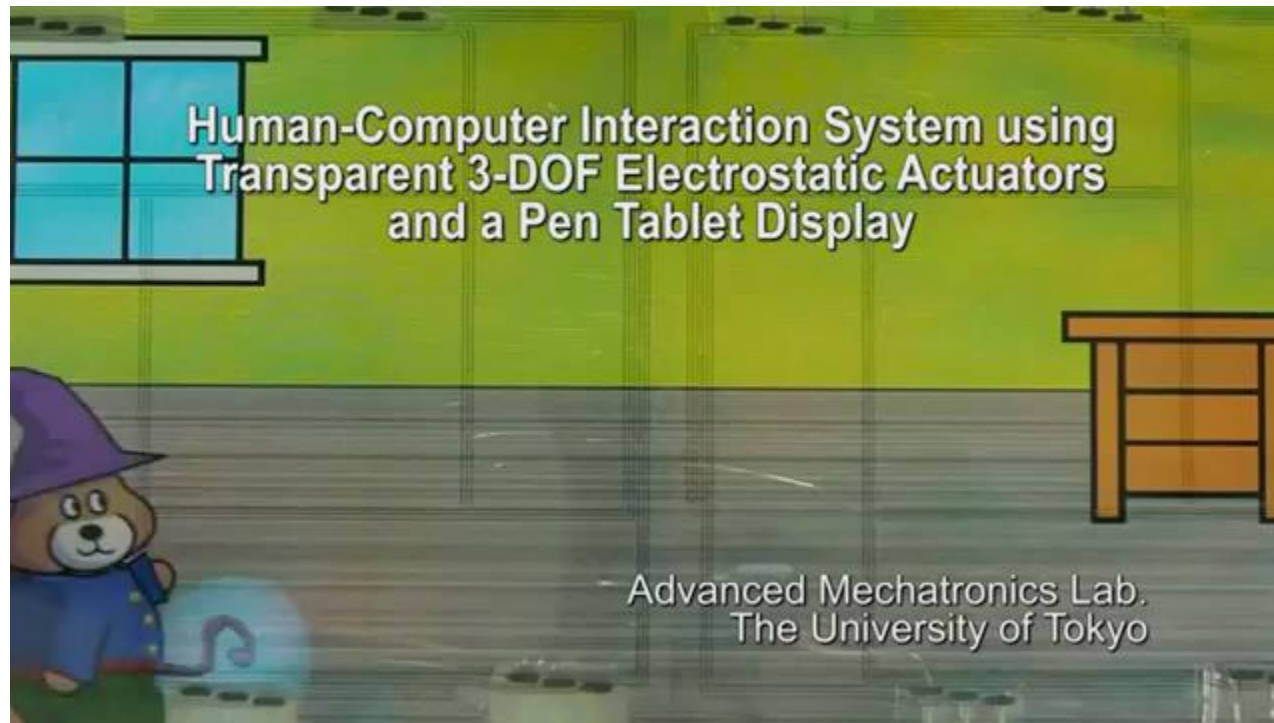


Squeeze film effect

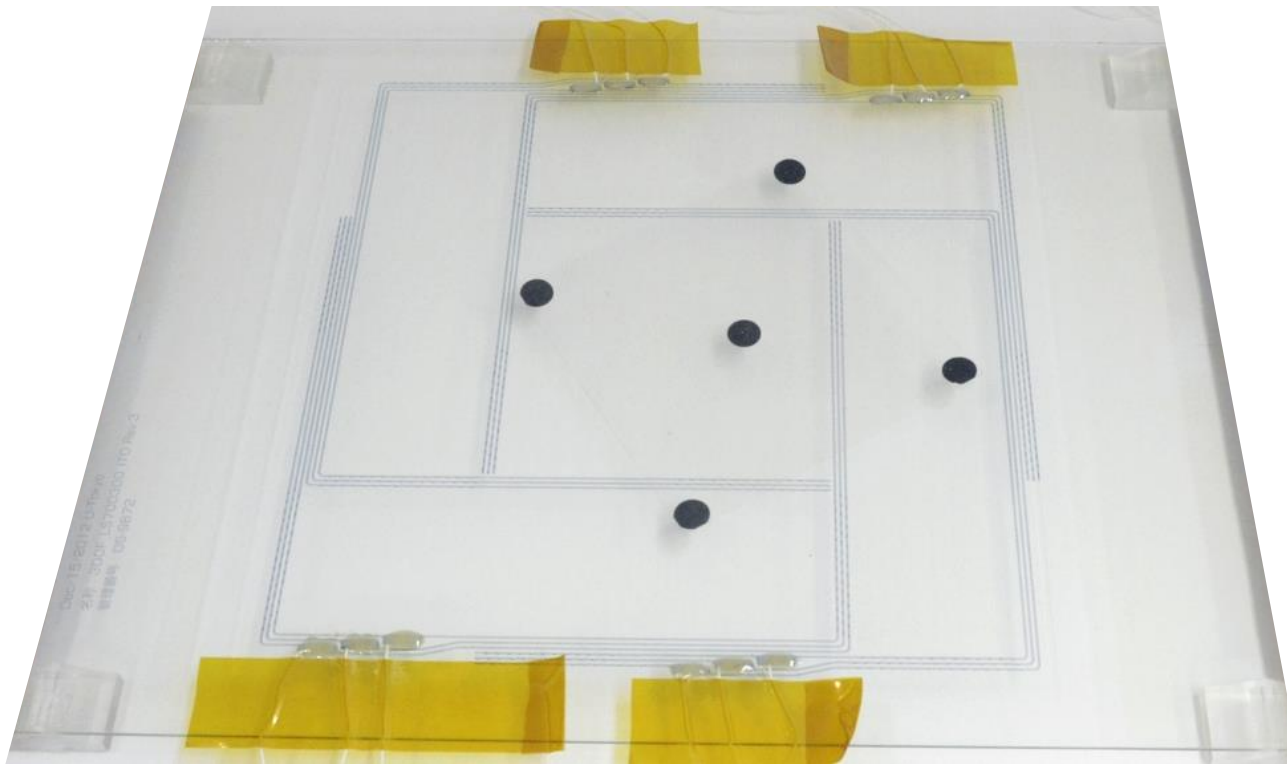
The squeeze-film effect is the effect whereby a very thin layer of gas gets trapped between parallel surfaces if these are kept in relative motion versus one another.



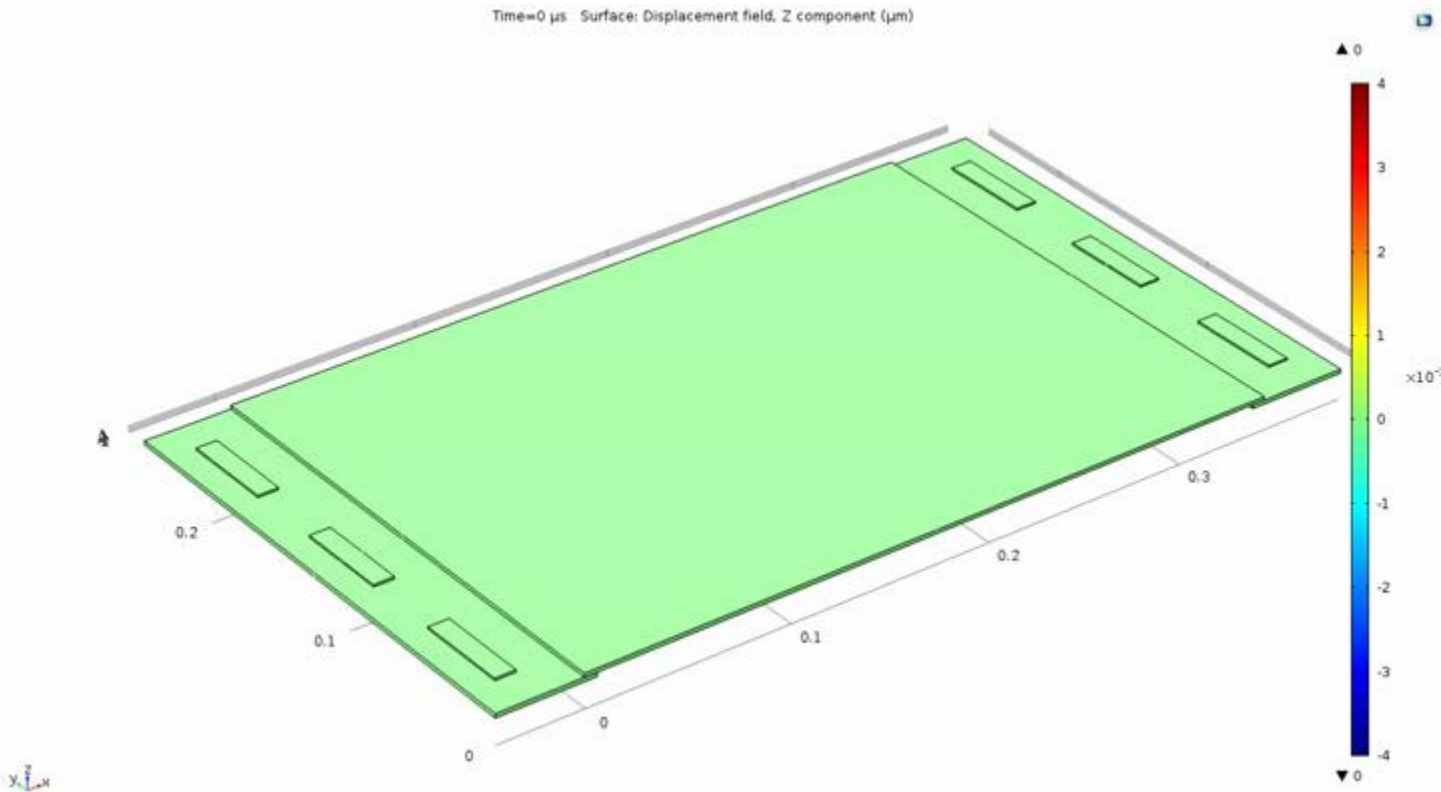
Electrostatic Surface Actuator



System design

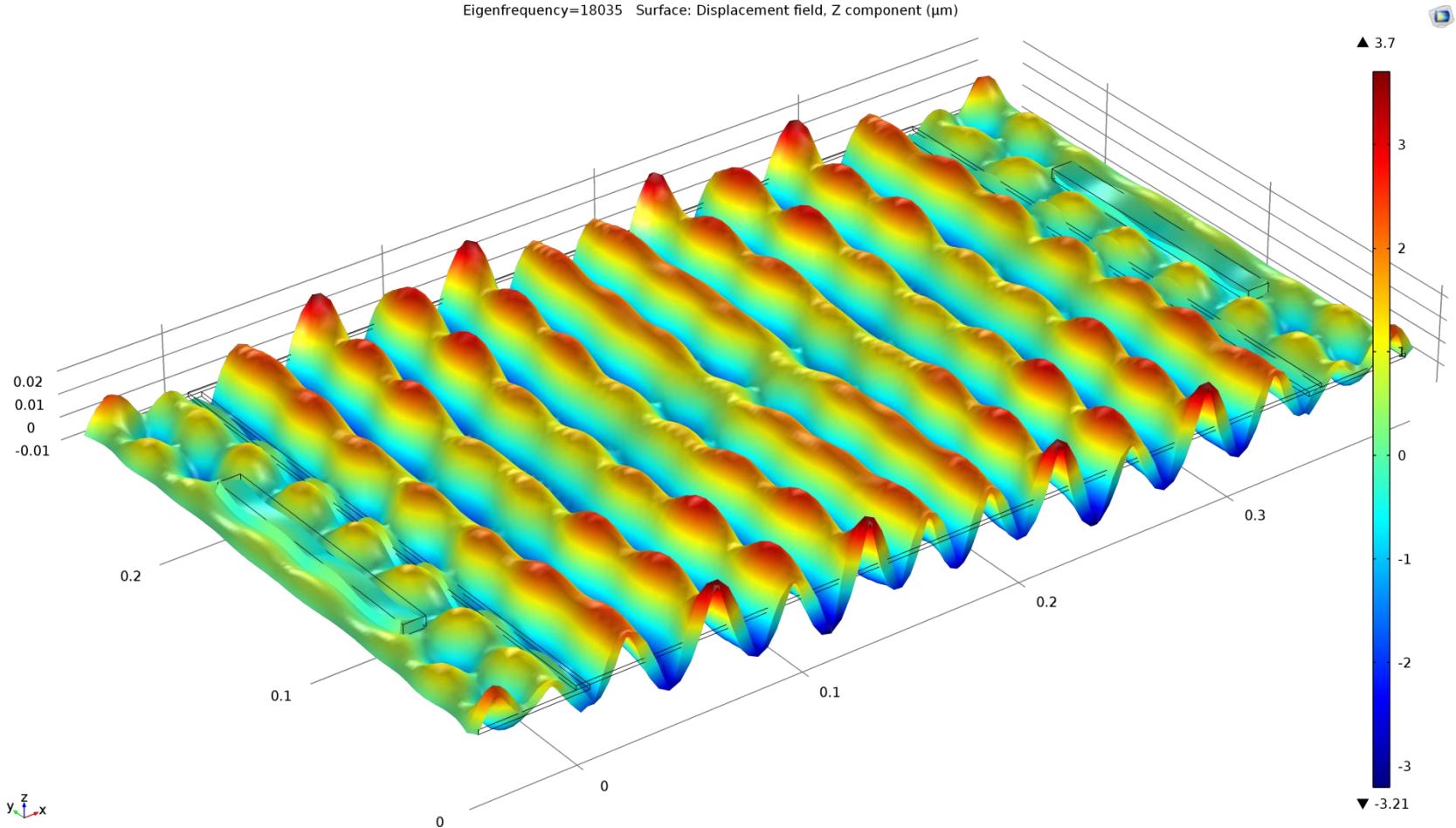


System design

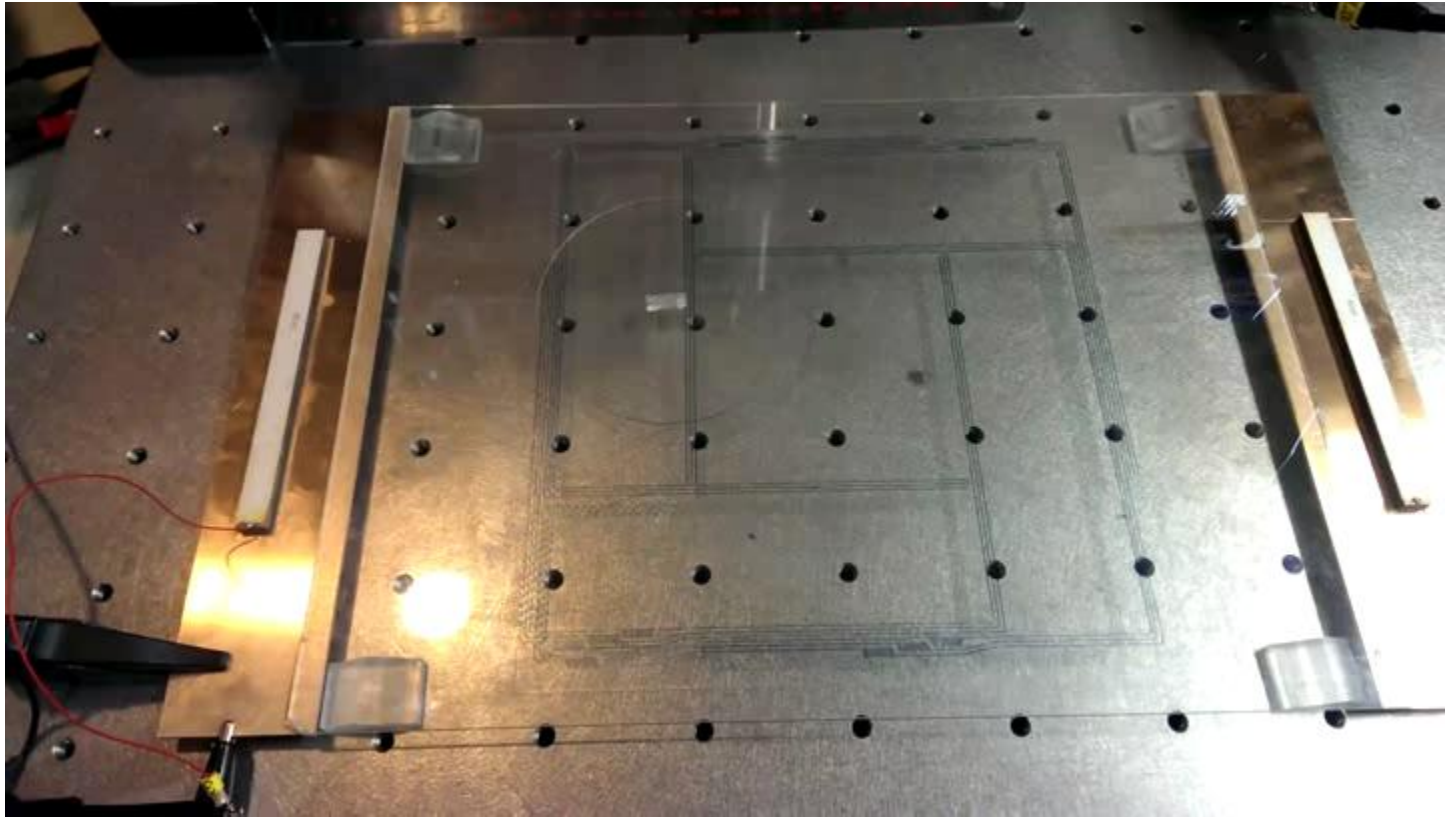


System design

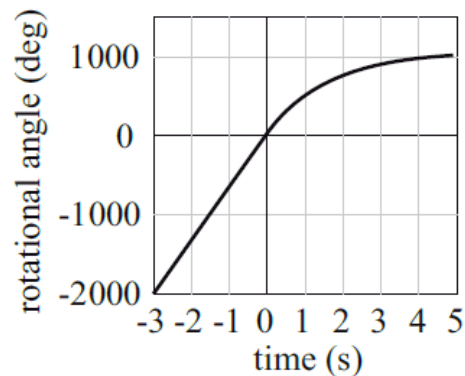
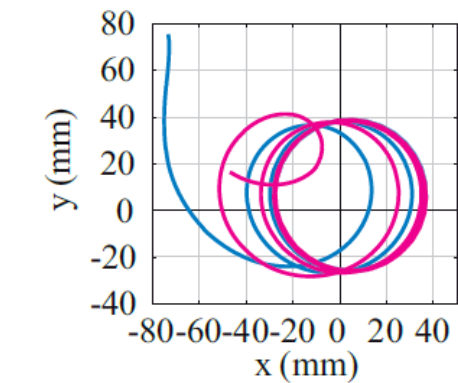
Eigenfrequency=18035 Surface: Displacement field, Z component (μm)



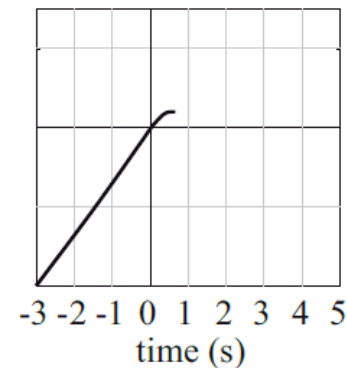
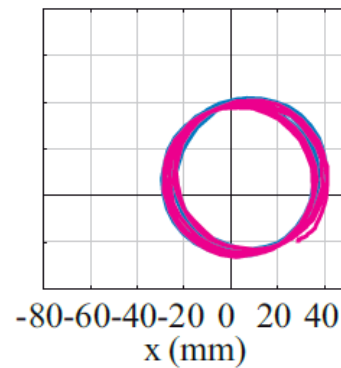
Final system test



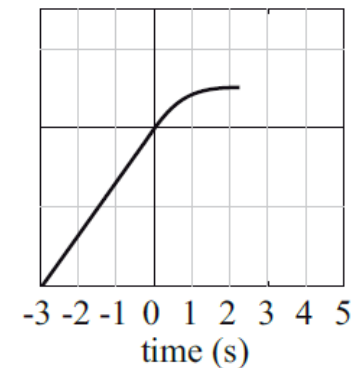
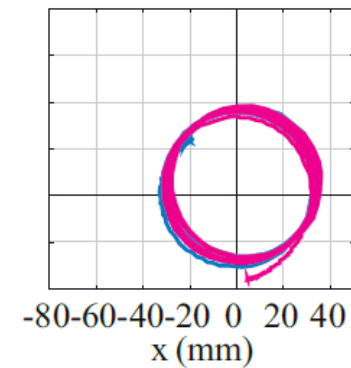
Results



- Vibration ON
- ElStatic OFF



- Vibration OFF
- ElStatic ON

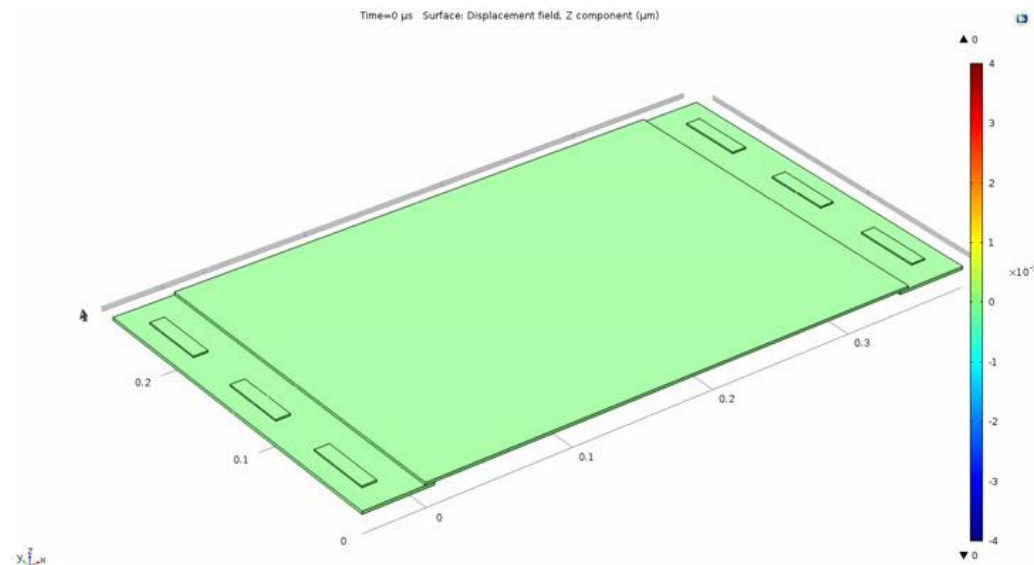


- Vibration OFF
- ElStatic OFF

Conclusions

Ultrasonic lubrication:

- Very promising technology
- Can be considered an emerging trend with much hidden potential



Thank you for your attention!